What are Performance Measures and Performance Indicators output by the Hydrologic Models?

Hydrologic models are used to understand and simulate the potential effect water management projects may have on the natural and managed systems. The output from these models are stages (water levels) and flows (volume) for each cell in the model's grid for each time-step (daily). For each cell or group of cells within the model boundary, the stage and flow may be summed or averaged for a specified duration (daily, weekly, monthly, annually or multiple years). The stage and flow data can be displayed in the form of tables, histograms, xy line graphs, bar graphs or color-coded maps. These different types of displays are generally referred to as performance measures and indicators whether the output is from the South Florida Water Management Model (SFWMM) or the subregional groundwater (MODFLOW) models. A significant difference between the SFWMM and MODFLOW models is that the SFWMM simulates 31-years of climatic record (1965-1995) while the subregional models simulate 2-years of climatic record (1989-1990), which includes a 1-in-10 year drought period.

Performance measures are quantitative indicators of how well (or poorly) an alternative meets a specific objective. Features of good performance measures are that they are:

- Quantifiable,

- have a specific target,

- indicate when that target has been reached, or

- measure the degree of improvement toward the target when it has not been reached

Achieving hydrologic targets does not necessarily guarantee ecological restoration of natural areas nor does achieving hydrologic targets in the Lower East Coast Service Area necessarily guarantee future water supplies. It does provide the best available indication of future conditions, and this information can be used as a basis for decision making in terms of directing ecological recovery and water supply allocation.

Performance Indicators, in contrast to performance measures, do not have a specific target, but are used to provide an indication of the relative behavior of alternatives. For example a stage hydrograph without specific stage targets is considered a hydrologic performance indicator.

A brief description of some of the types of performance measures and performance indicators are listed below. Performance measures are not separated from performance indicators; they are listed together. On the web page the performance measures (including indicators) will be organized geographically into those pertaining to particular regions. Performance measures that pertain to the entire modeled domain have been placed in a regional group.

Performance Measure Sets and Model Runs

Each **RUN** is the model output for particular base cases and scenarios. For example, LEC 2020 with Restudy, the Current LEC 1995 Base Case, and the Future LEC 2020 Base Case, are all

runs.

A performance measure **SET** is the group of model simulation runs that are compared. For example, a set may compare the Current LEC 1995 Base, Future LEC 2020 Base Case, and LEC 2020 with Restudy.

To view the performance measures a particular SET must be selected on the web page. The selection of a set of performance measures may be changed at any time while using the web page.

Types of Performance Measures

Different types of performance measures are displayed for each geographical region. In some cases, the type of measure is specific to that particular region while in many cases it is common to all regions. It should be noted that during the Restudy, many targets were based on the performance of the Natural System Model (NSM). The NSM simulates the pre-drainage Everglades and is used in conjunction with the SFWMM to understand how the drained system performs in comparison to simulated historical conditions. The Natural System Model (NSM) output is not comparable to output from the subregional groundwater models and will not be used in conjunction with them. Hydrologic targets will be set for the natural areas appropriate for the subregional groundwater models.

Weekly Stage hydrographs

Stage hydrographs represent the time series of a water stage at a particular location (typically, the value of a grid cell - 500' x 500' or 2 miles x 2 miles depending on the model used). Stage hydrographs can be used to compare hydrograph characteristics with those of different alternatives at the specific location, providing information on how well each alternative performs with regard to the duration and severity of seasonal water level fluctuations, minimum and maximum levels, the occurrence and frequency of dry out or the duration and severity of water restrictions. Hydrographs are located throughout the model area in wetlands, near Restudy components, wellfields, and along the coast.

Stage duration curves

Stage duration curves provide an indication of the cumulative probability that a particular stage is exceeded or not exceeded. Stage duration curves are produced at the same locations as the stage hydrographs. From the duration curve the probability of exceeding a given stage is easily quantified for each alternative. It is useful to understand how the area performs during the high and low water extremes.

Normalized stage hydrographs and duration curves

Normalized stage hydrographs and normalized stage duration curves are used to reference stages with respect to land elevation rather than NGVD to facilitate comparison of ponding depths. When applying the SFWMM, this is important in comparing stages from different alternatives with the NSM values where land subsidence has occurred. For the subregional groundwater models, normalization facilitates understanding the ponding frequency and duration of wetland

systems, while comparing ground water heads measured relative to NGVD is useful for understanding water levels near the salt-water interface or wellfields.

Hydroperiod distributions and matches

Hydroperiod distribution maps of the model area and histograms indicate the total area inundated for 30-day inundation period classes for each of the alternatives compared. For the subregional models, a hydroperiod distribution map for each model displays the spatial distribution of the average hydroperiod. In addition, a histogram is generated for each natural areas of interest summing the acreage in each hydroperiod class. Both the map and the histogram are divided into 30-day inundation period classes.

For the SFWMM, cell by cell maps and histograms of the hydroperiod distribution were developed to determine how well pre-drainage spatial inundation patterns are reproduced by each alternative. Cell by cell comparisons determine how alternatives compare to, or match, the pre-drainage system as simulated with NSM at each modeled grid cell and indicate where changes have taken place. Hydroperiod histograms measure conditions over an area or for a particular landscape.

Hydroperiod matches histograms quantify the area that matches the inundation pattern simulated by the NSM for each alternative and provide a quick overview of the regional performance. Inundation patterns within plus or minus 30 days of those of the target are considered to match NSM. Histogram classes quantify the areas that have either longer or shorter inundation periods than NSM. This is applied only to those areas where NSM is the target.

Groundwater Flows and Heads and Overland Flows

The subregional groundwater models segregate the surficial aquifer system into multiple layers (see about models). The top layer simulates wetlands and soil transmissivity. Simulations of the top layer (layer 1) enable the reviewer to understand how wetlands and other natural features perform. The production zone (layer 2 or 3 depending on the model) generally simulates the most productive area of the aquifer. Review of the groundwater heads in this layer provides insights of the effects of groundwater withdrawals.

To understand how water flows across large spatial areas, animations of the direction and the magnitude of volume of water flows are displayed. For each model area, the change in the direction and volume of groundwater flows over time can be viewed. These changes provide a general understanding or an overview of how flows are affected. For the subregional models, groundwater flows are simulated for the water table (generally layer 1), while the SFWMM generates overland flow maps.

Groundwater heads, or the elevation of the water table, as simulated by the subregional models can be displayed for large areas as well. Groundwater heads are generated for each cell in the model area, then grouped together to display groundwater gradients. Changes in the gradients overtime is animated for the period of record for the water table and production zone (where public water supplies are withdrawn).

To compare changes in groundwater heads between runs, groundwater head differences are generated. A cell's groundwater head at a specific date in the period of record in a run is

compared to the groundwater head for the same location and date in another run. The groundwater heads differences for the cells in a model's area are animated for the water table (layer 1) and the production zone (layer 3 or 4 depending on the model).

Indicator Regions

Performance of component designs will be evaluated in selected regions in natural areas. These "indicator" regions, typically represent hydrologically distinct areas of interest, and are strategically located throughout the Lower East Coast Service Area, Water Conservation Areas and Everglades National Park. Indicator regions are intended as tools to examine the hydrological behavior of small, subregions in the remaining Everglades. Use of indicator regions to average model output over multiple, similar cells avoids single cell comparisons and permits model output to be examined on a larger scale. Performance measures and indicators for these regions include Weekly Normalized Stage Hydrograph, Weekly Normalized Stage Duration Curve, High and Low Water Level Summary Tables, Inundation Duration Summary Table and seasonal and interannual variability.

Water Budget

The water budget performance measures present graphically the volume of water that comes into (positive) or leaves (negative) an area on average annually. Each term of the water budget is shown for each alternative. Water budget terms include rainfall, evapotranspiration, groundwater flows, structure flows, public water supply withdrawals, and changes in storage. A residual term is also shown to verify conservation of mass and accounting. These will be applied to larger areas, each Lower East Coast Service Area for example, in the SFWMM and to smaller geographic areas, i.e., drainage basins, in the subregional groundwater models.

Groundwater and Overland Flow Transects

Groundwater flows are integral to several performance measures and indicators. Groundwater flows across a transect are summed for a specific duration. Transects are usually located near a water management feature or along the east coast protective levee to understand how the magnitude and timing of water flows are affected. To measure seepage from the Water Conservation Areas and Everglades National Park to the Lower East Coast Service Areas, transects are located along the levees. Generally, the subregional models measure groundwater flows and the SFWMM measures overland flows at the transects.

Water Supply Restrictions

There are several performance measures that characterize the severity and duration of water supply cutbacks imposed on legal water users when regional or local storage is diminished during droughts. Water supplies are cutback due to low groundwater stages in selected "trigger" cells in the Lower East Coast, low surface water stages in Lake Okeechobee or continuation of the restriction in the dry season. The subregional groundwater models divide the LEC Service Areas into "Water Restriction Areas" to more accurately reflect how the District's water shortage policy may be implemented. All water supply graphics in the LEC Service Area are based on these water restriction areas. In groundwater models, maps display the location of trigger cells and the frequency and severity of any cutbacks, bar charts display the percentage of demands met and not met by use type as well as the monthly volume of cutbacks for each water restriction

area, and stage hydrographs are produced for the trigger cells in the Lower East Coast Service Area.

1-in-10 Level of Certainty

Wetland Drawdowns: One of the concerns with withdrawals from the Biscayne Aquifer and surface waters is the potential to impact wetlands. By comparing runs with and without public water supply, irrigation and agricultural withdrawals, the effect of these consumptive uses can be evaluated. When the difference in heads within a wetland is one foot or greater for 30 days, it is tallied and displayed on a map of the model area. This is similar to the consumptive use criteria for permits. This performance indicator is only applied to the subregional groundwater models in the LEC Service Area.

Net Inflow of Saltwater along the Coast: Another concern is whether withdrawals may affect the saltwater interface. If the groundwater flow east towards the coast is less than the flow west towards a wellfield, the saline interface has the potential to move. By measuring groundwater flows east and comparing them to westward flows, the NET inflow can be calculated. Only when the net flow to the west is greater is the magnitude of the flow indicated. When reviewing this performance indicator, note that the net flow is calculated for all layers of the model. Results include the surface water as well as the production zone. This performance indicator is only applied to the subregional groundwater models in the LEC Service Area.

Restudy Components

Monthly Summary Report for Restudy Components: Monthly summary reports for the Restudy reservoirs and storm water treatment areas, for example the Hillsboro Impoundment, provide information useful to understand how the component operates in the subregional groundwater models. Types of information included are rain, evapotranspiration, seepage, inflows, discharges, and changes in storage.

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